

# Marine Phytoplankton Monitoring in Central Puget Sound: Small Organisms, Big Value

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## INTRODUCTION

The King County Marine & Sediment Assessment Group manages a long-term marine monitoring program designed to assess water quality in the Central Puget Sound Basin. Data are collected monthly for physical, chemical, and biological (chlorophyll-*a* and bacteria) parameters at 14 locations throughout the Central Basin. The recent addition in 2008 of a long-term phytoplankton species component to this program at selected sites was deemed necessary to predict how changes in climate and other regional stressors might impact the Sound's trophic structure. Phytoplankton abundance and species composition provide valuable information as they are sensitive integrators of their environment.

Goals of the phytoplankton monitoring program are:

- assess the relative abundance of major phytoplankton taxa ;
- document the timing of seasonal shifts;
- investigate relationships between physical/chemical parameters and species relative abundance;
- detect long-term changes in community composition;
- create a photo library by July 2012: [green.kingcounty.gov/marine/photos.aspx](http://green.kingcounty.gov/marine/photos.aspx); and
- collect a long-term dataset to help evaluate potential changes in the Puget Sound food web.

Phytoplankton results from 2008-2010 are presented.

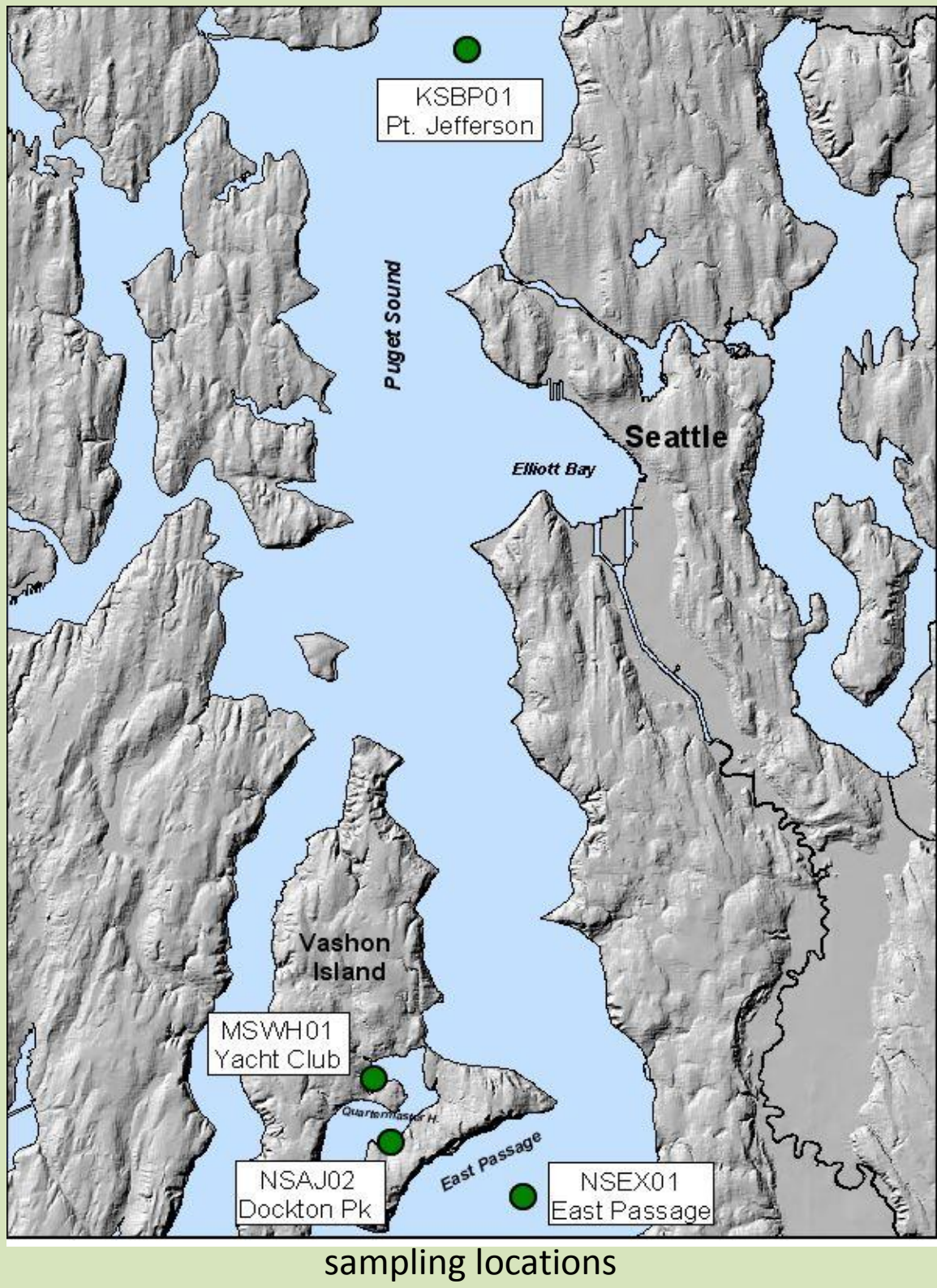
## METHODS

### Sample Locations

Samples are collected bi-weekly April through October at 3 stations (see map).

**Point Jefferson** and **East Passage**: Long-term ambient monitoring stations representing open north and south areas of the Puget Sound Central Basin.

**Quartermaster Harbor**: Shallow, protected embayment with poor tidal flushing. Telemetered mooring provides high frequency water quality data from this site. Sample site moved from the inner harbor (MSWH01) in 2008 to the current mid-harbor location at Dockton Park (NSAJ02).



### Sample Collection

- East passage and Pt. Jefferson samples are collected with Niskin bottles at 1m and the chlorophyll-*a* maximum layer
- Quartermaster Harbor samples are collected with a modified Scott bottle at maximum depth

### Analyses

**Chemical, Physical, & Biological Parameters:** Nitrate+nitrite, ammonia, orthophosphate, silica, temperature, salinity, dissolved oxygen, chlorophyll-*a*, bacteria measured in discrete water samples at all stations.

### Taxonomy

- Semi-quantitative analysis of concentrated live and preserved (0.4% formalin) samples.
- Taxa identified and relative abundance (Dominant, Subdominant, or Present) assigned according to dominance in nine microscopic fields: Dominant = prevalent in at least 50% examined fields; Subdominant = prevalent in at least 25% of examined fields; Present = present but does not fit above categories.
- Nikon 80i microscope with phase and differential interference contrast at 100-600x magnification and Nikon digital camera system. Used with Palmer-Maloney type counting chamber (PhycoTech, 0.06ml).

## RESULTS

- A total of 108 genera or species have been identified from 2008-2010 samples (57% diatoms, 37% dinoflagellates, 6% other taxa).
- Diatoms (mostly *Chaetoceros* hyalochaete species) have dominated throughout most of the sampling season, with the highest proportion of species during the spring bloom (April-June) followed by an increase in dinoflagellate species (July-August).
- *Pseudo-nitzschia* spp. (large forms) were present in most samples and were occasionally dominant at all three stations.
- *Alexandrium catenella* was present at the two southern stations, becoming occasionally dominant in Quartermaster Harbor. *Dinophysis* spp. were present every year at all stations but never in large numbers.
- Blooms of *Heterosigma akashiwo* were sporadic between July and September, extending to all three sites in 2009. When observed, this species was dominant 50% of the time.
- Some centric diatoms were common in the open water stations (e.g., *Thalassiosira* and *Actinopterychus*) but not in Quartermaster Harbor.
- Dinoflagellate relative abundance did not increase until summer in all three sampling years. The first week in July was the earliest any dinoflagellate species was either dominant or subdominant.
- *Ceratium fusus* was the most frequent dominant/subdominant dinoflagellate species at the two open water stations.
- The June 2009 bloom at Point Jefferson, comprised mainly of the diatoms *Rhizosolenia setigera* and *Chaetoceros* hyalochaete species, was so large that both nitrate and silica were depleted from the water column.

### Frequently Identified Species

	KSBP01	NSEX01	Quartermaster H.
	2008	2009	2010
<b>Diatoms:</b>			
<i>Actinopterychus senarius</i>			
<i>Asteromphalus heptactis</i>			
<i>Chaetoceros (Hyalochaete) sp.</i>			
<i>Chaetoceros (Phaeoceros) sp.</i>			
<i>Chaetoceros debilis</i>			
<i>Chaetoceros decipiens</i>			
<i>Chaetoceros dialytus</i>			
<i>Chaetoceros eibeni</i>			
<i>Chaetoceros socialis</i>			
<i>Chaetoceros vanheurckii</i>			
<i>Coscinodiscus sp.</i>			
<i>Cylindrotheca closterium</i>			
<i>Detonula pumila</i>			
<i>Ditylum brightwellii</i>			
<i>Eucampia zodiacus</i>			
<i>Guinardia delcatula</i>			
<i>Hemiaulus haukii</i>			
<i>Leptocylindrus danicus</i>			
<i>Nitzschia acicularis</i>			
<i>Pleurosigma sp.</i>			
<i>Pseudo-nitzschia americana</i>			
<i>Pseudo-nitzschia sp. (large)</i>			
<i>Rhizosolenia setigera</i>			
<i>Skeletonema costatum</i>			
<i>Thalassionema nitzschoides</i>			
<i>Thalassiosira nordenskiöldii</i>			
<i>Thalassiosira rotula</i>			
<i>Thalassiosira sp.</i>			
<b>Dinoflagellates:</b>			
<i>Ceratium fusus</i>			
<i>Dinophysis acuminata</i>			
<i>Dinophysis acuta/norvegica</i>			
<i>Dinophysis sp.</i>			
<i>Noctiluca scintillans</i>			
<i>Prorocentrum gracile</i>			
<i>Prorocentrum conicum</i>			
<i>Prorocentrum depressum</i>			
<i>Prorocentrum sp.</i>			
<i>Prorocentrum steinii</i>			
<i>Scrippsiella trochoidea</i>			
<b>Silicoflagellates:</b>			
<i>Dictyocha speculum</i>			

Taxa identified in over 50% of the total number of samples.

### Dominant and Subdominant Species, 2008 - 2010

	Point Jefferson	East Passage	Quartermaster Harbor
<b>April</b>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Thalassiosira sp.</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Thalassiosira sp.</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Coscinodiscus sp.</i> <i>Skeletonema costatum</i> <i>Chaetoceros (Hyalochaete) sp.</i> <i>Detonula pumila</i>
<b>May</b>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Detonula pumila</i> <i>Thalassiosira sp.</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Thalassiosira sp.</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Detonula pumila</i> <i>Thalassiosira sp.</i>
<b>June</b>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Eucampia zodiacus</i> <i>Pseudo-nitzschia sp.</i> <i>Rhizosolenia setigera</i> <i>Skeletonema costatum</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Thalassiosira sp.</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Chaetoceros convolutus</i> <i>Rhizosolenia setigera</i> <i>Prorocentrum gracile</i>
<b>July</b>	<i>Cylindrotheca closterium</i> <i>Pseudo-nitzschia sp.</i> <i>Skeletonema costatum</i> <i>Prorocentrum gracile</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Chaetoceros convolutus</i> <i>Coscinodiscus wailesii</i> <i>Eucampia zodiacus</i> <i>Rhizosolenia setigera</i> <i>Ceratium fusus</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Chaetoceros convolutus</i> <i>Rhizosolenia setigera</i> <i>Prorocentrum gracile</i>
<b>August</b>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Detonula pumila</i> <i>Thalassiosira rotula</i> <i>Heterosigma akashiwo</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Skeletonema costatum</i> <i>Ceratium fusus</i> <i>Heterosigma akashiwo</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Leptocylindrus danicus</i> <i>Prorocentrum gracile</i> <i>Heterosigma akashiwo</i>
<b>September</b>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Ceratium fusus</i> <i>Alexandrium catenella</i> <i>Alexandrium sp.</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Thalassiosira sp.</i> <i>Thalassiosira sp.</i> <i>Pseudo-nitzschia sp.</i> <i>Alexandrium catenella</i> <i>Ceratium fusus</i> <i>Heterosigma akashiwo</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Alexandrium catenella</i> <i>Prorocentrum gracile</i> <i>Heterosigma akashiwo</i>
<b>October</b>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Pseudo-nitzschia sp.</i>	<i>Chaetoceros (Hyalochaete) sp.</i> <i>Leptocylindrus minimus</i> <i>Thalassiosira sp.</i>	<i>Pseudo-nitzschia sp.</i> <i>Alexandrium sp.</i>

HAB or potentially harmful species are in red.

### Proportion of Diatom Species in Each Sample

% Diatom Species	week	2008			2009			2010		
		KSBP01	NSEX01	MSWH01	KSBP01	NSEX01	NSAJ02	KSBP01	NSEX01	NSAJ02
April	1	--	--	46.7	75.0	62.0	76.9	87.9	86.1	88.4
	3	100.0	86.1	--	82.9	83.8	92.1	75.5	79.4	77.1
	5	85.8	72.4	37.5	77.1	76.9	76.0	92.0	82.2	87.1
May	3	55.6	58.3	36.4	77.4	83.3	85.7	80.9	85.7	90.9
	1	--	--	--	77.8	61.2	63.6	71.8	87.5	80.0
	3	75.0	72.7	76.9	71.9	61.8	52.9	64.3	66.7	76.5
June	1	65.2	41.7	73.3	40.7	57.1	30.0	60.0	52.2	74.5
	3	52.9	58.8	46.2	87.0	58.6	45.0	57.7	82.6	66.7
	5	50.0	60.0	45.4	84.5	47.0	55.6	69.6	85.7	64.7
July	3	63.4	57.1	45.0	47.4	52.3	27.3	58.3	80.0	85.0
	1	66.7	68.2	35.3	--	55.5	50.0	64.7	67.6	73.1
	3	65.7	66.7	40.0	55.6	63.3	58.8	70.4	76.9	50.0
August	1	73.9	73.3	72.2	70.0	63.3	45.0	--	--	--

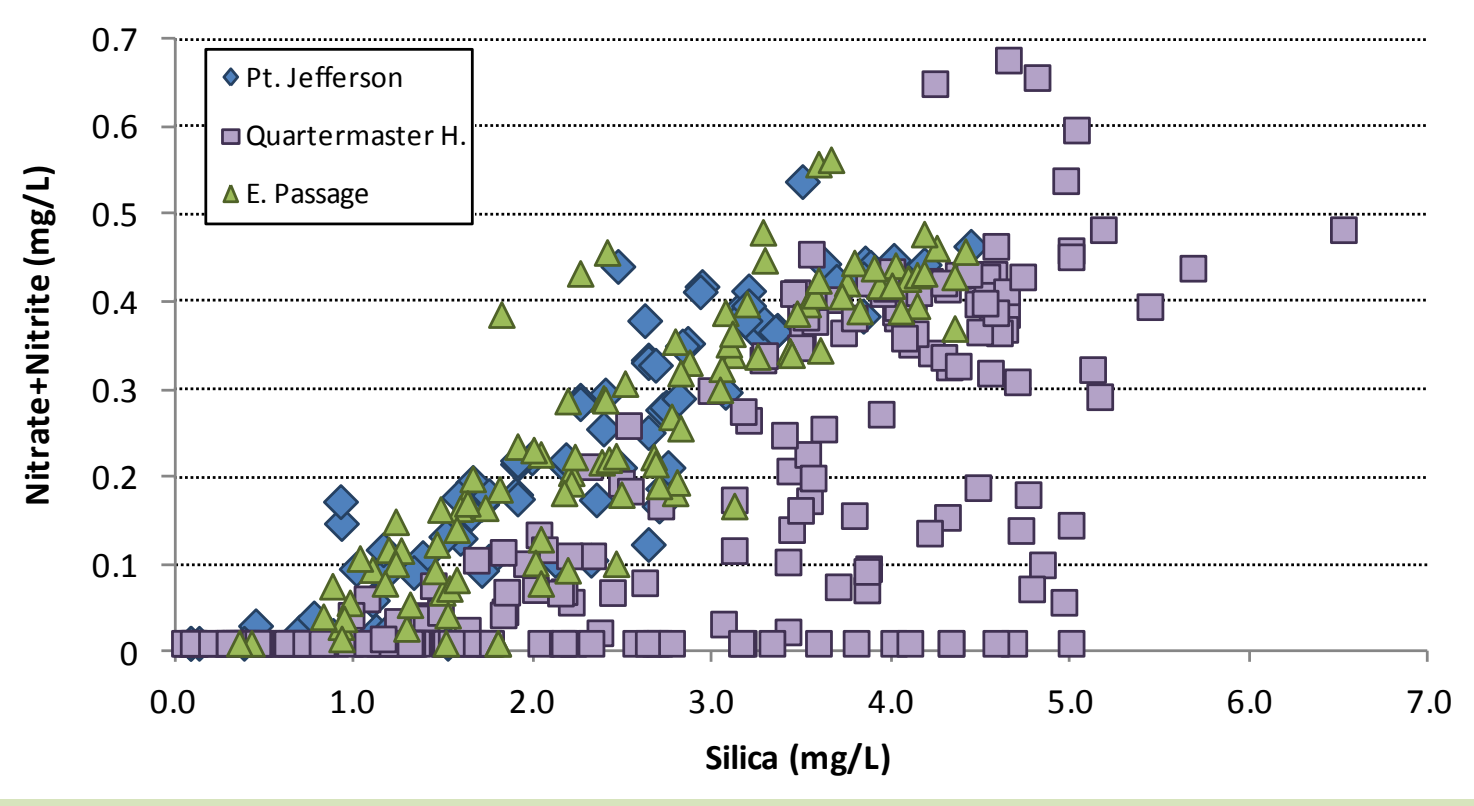
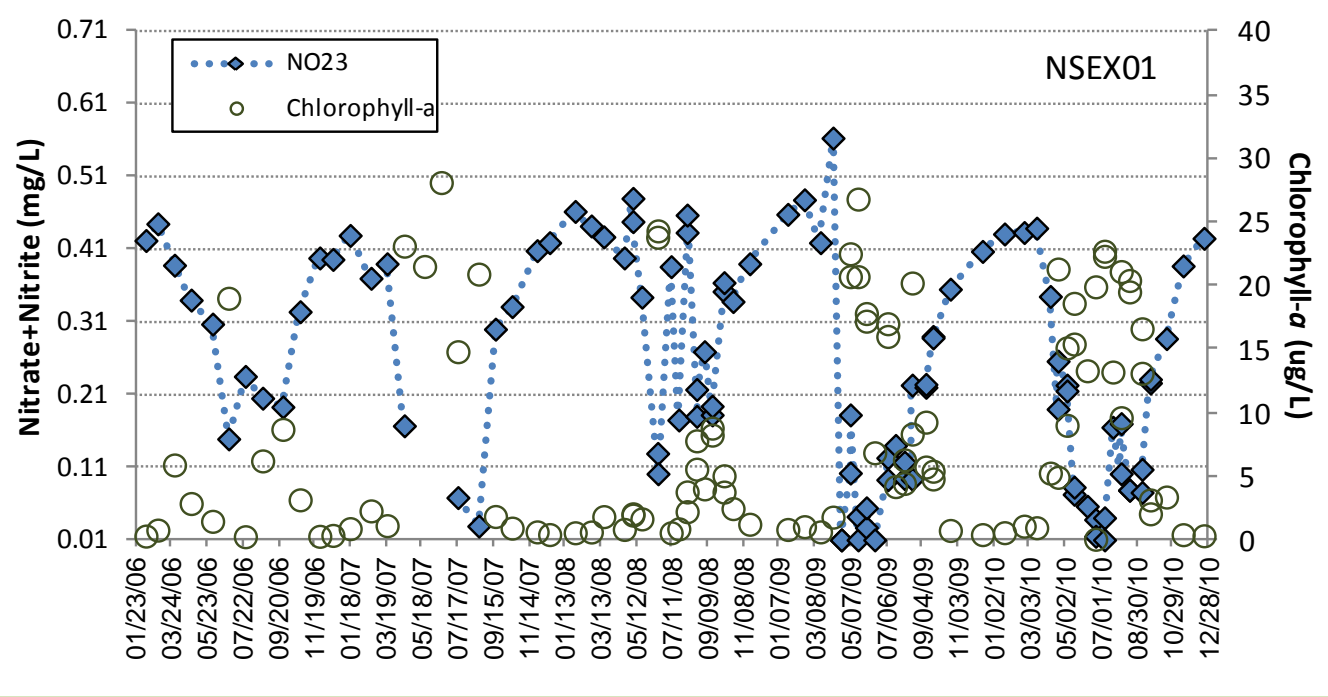
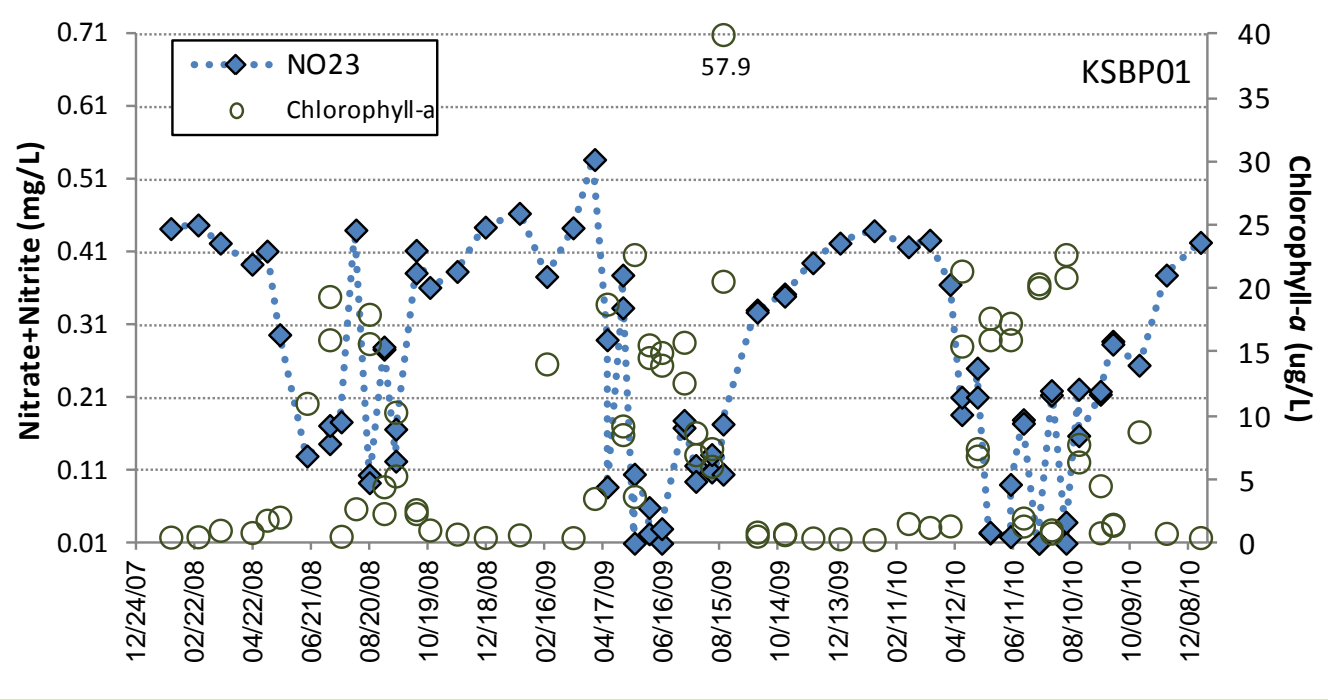
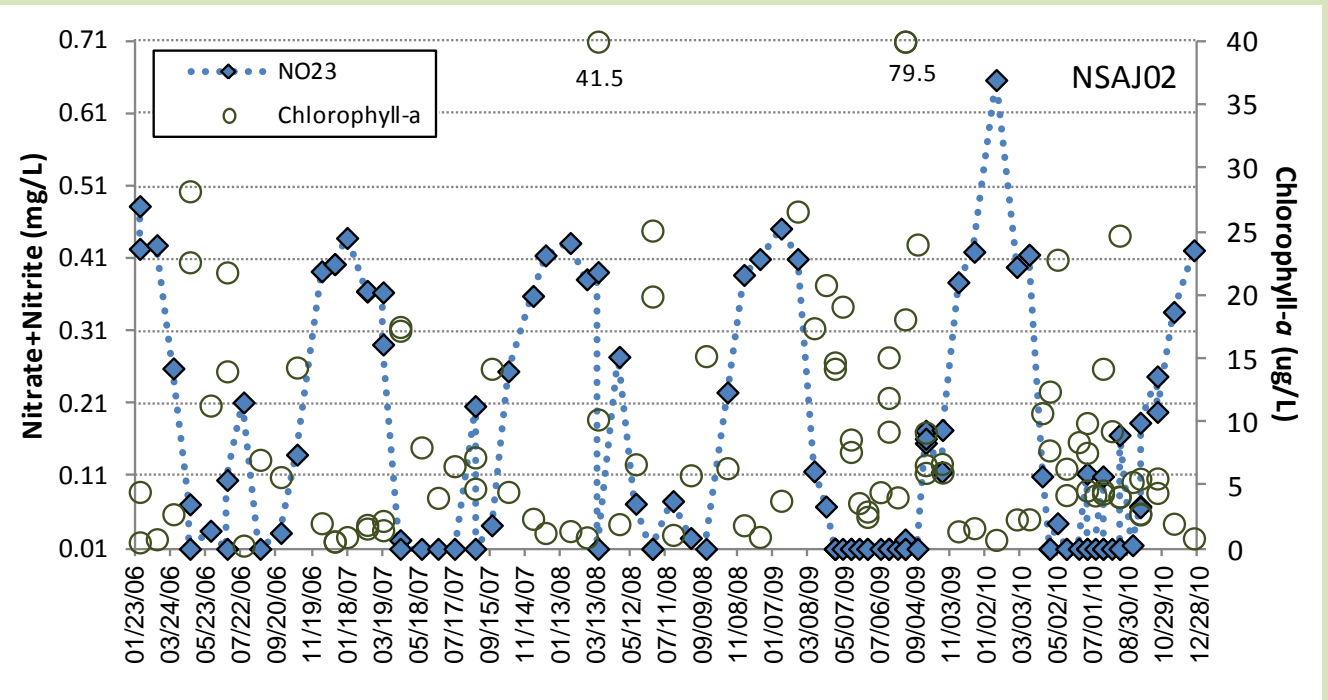
≤50

51-74

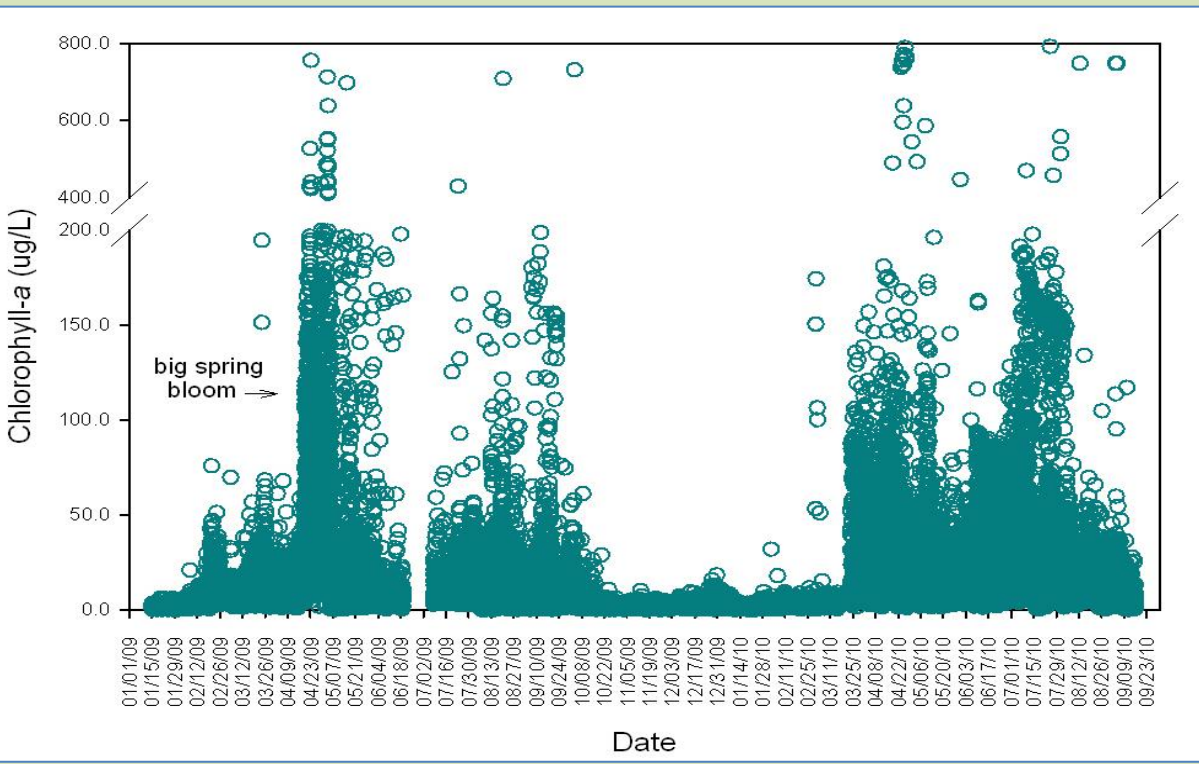
≥75

October 2009 is week 3.

\* October 2009 is week 3.



Nitrate and silica follow a similar seasonal pattern for both open water stations (Point Jefferson and East Passage), as shown by a tight correlation in the figure above. Quartermaster Harbor silica levels are generally higher and more variable, but often fall below the detection level when diatoms are dominant.



*In vivo* chlorophyll-*a* fluorescence data at Dockton mooring (15-minute intervals) show spring and summer blooms during 2009 and 2010.

## Challenges

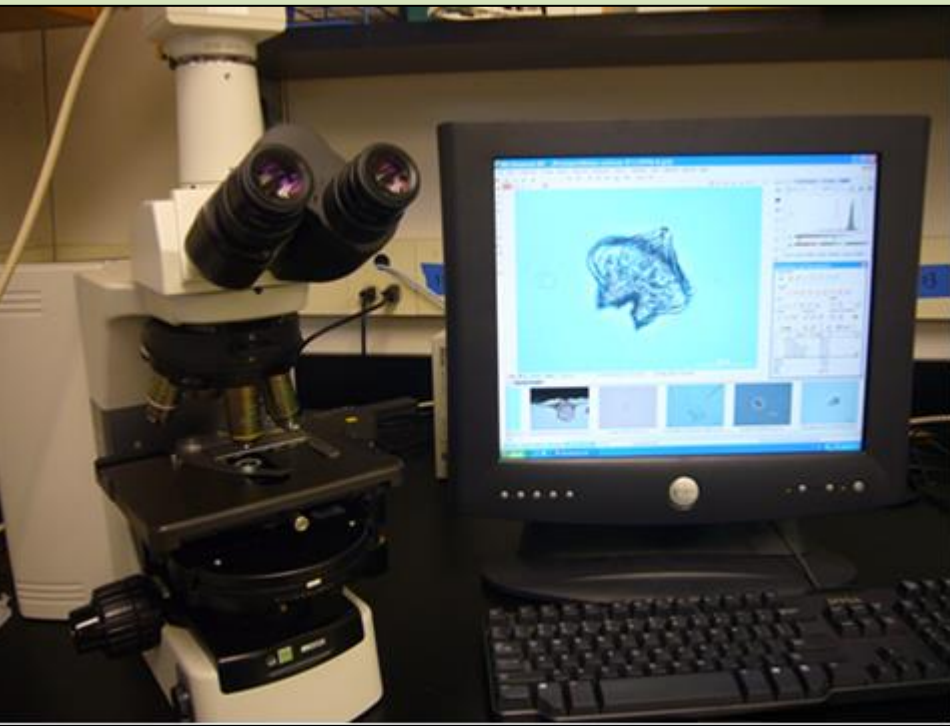
Marine phytoplankton monitoring programs are rare due to their labor intensive nature, taxonomic difficulties, and uncertainties from sampling a highly patchy and variable environment. Our semi-quantitative approach allows us to continue with limited resources, yet presents a greater challenge for data analysis and interpretation. Future directions may include analysis of photosynthetic pigments or image analysis technology in order to add a quantitative dimension to this dataset.



Niskin bottles



settling in formalin



microscope and imaging software



concentrating live samples using reverse filtration

